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ABSTRACT

Teacher process variables and student outcomes were examined as they appeared in two settings employing curriculum materials based on alternate psychological learning approaches. The two settings were based on the cognitive restructuring and behavioral approaches described by Bruner and Gagne, respectively. Ten teachers were involved in the study. Five videotaped teaching episodes were collected and coded for each teacher. Student outcomes were measured in the areas of interest, achievement, cognitive style, and self-concept. Results indicate differences between the two treatment groups in selected areas of both the teacher process variables and the student measures. (Author)

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THE IDENTIFICATION OF TEACHER PROCESS VARIABLES AFFECTING STUDENT OUTCOMES IN TWO ALTERNATIVE SCIENCE CURRICULUM TREATMENT SETTINGS*

by

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in New York, April 1977

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Introduction*

Assuming that what teachers do has some effect upon what children learn, the question of teacher effectiveness should occupy a central role in educational research. Attempts to examine variables related to teacher effectiveness have a long history in the literature of education. From the earlier studies attempting to identify the characteristics of teachers whom students perceived as "good" teachers to those focussing on the devising and application of rating scales, research in the 1960's and 1970's turned to process product studies where attempts were made to relate teacher process variables to pupil gain scores (Medley and Mitzel, 1959; Medley, 1973; Rosenshine and Furst, 1971).

Despite the lack of positive and consistent results from much of this research (Duncan and Biddle, 1974; Heath and Nielsen, 1974), two points are evident. First, interest continues. The NARST-NIE

* Sections of this paper are taken from a revision of a paper given in San Francisco at the Annual AERA meeting in April 1967 entitled "A Search for Variables to Assess Teacher Effectiveness".

Commission on Research in Science Education recently identified teacher characteristics and their influence upon transactions and outcomes as having a high priority in research in science teaching (NARST, 1975). Second, much is being learned about the way in which such research should be conducted, consequently, the methodology has improved. As Duncan and Bidle point out "... the progression from concern with frequencies of acts to concern with the patterns formed by those acts over time is a sign of the increasing sophistication in research on teaching." (1974: 322)

Since the purpose of such research is to produce predictable and sustaining relationships between the things teachers do and what children learn, there are strong arguments for conducting the study of teacher effectiveness within the context of curriculum areas. There is the recognition that teachers use different approaches when they teach different subjects reducing the possibility of finding relationships general to all subject areas. Also, it is within curriculum areas that recent curriculum development has occurred and produced packages and models having clear intents in terms of teacher behaviour and student outcomes.

Two approaches taken in studies on process product studies within curriculum areas have each had their own inherent weaknesses. In one approach, what teachers do is defined in terms of a program or curriculum and attempts made to contrast treatment effects based on alternative approaches (Meyer, 1971; McGlathery, 1967; Howe and Butts, 1970; Wideen, 1975). The wide range of variables subsumed within treatments makes it difficult to ascertain what might actually

be contributing to differences that occur in student outcomes in this approach. A related problem in these studies is that the variation in the implementation of a program may not make it meaningful to try to contrast treatment effects (Cooley, 1974).

In the other approach, exemplified by the work of Worthen (1964), Guthrie (1967) and Rowe (1974), specific teacher variables have been used. In Worthen's Study, teacher direction and non-direction was used as treatment in comparing student achievement in mathematics. Guthrie used four instructional sequences based on rules and examples based on a similar paradigm. In both studies it seemed doubtful if the treatment generated sufficient power to alter a range of classroom transactions, considering other intervening variables. The work of Rowe, focussing on wait time was more productive in accounting for student behaviour than the other two. However, as in the other studies, one wonders if the variable considered was the most useful or powerful within the system. Why was it chosen over other possible variables?

In two recent studies (Good et al, 1975; Shymansky et al, 1975), links were found between the teacher variables and student structure and student outcomes. However, in summarizing their findings, Good suggested that further research should concentrate on identifying a variety of instructional variables for purposes of further inquiry. Cooley lends support to Good's suggestion in emphasizing that "... the actual education process under investigation must be directly observed and then represented as a multidimensional domain in the same way one considers outcomes (1974, p. 8).

In attempting to avoid some of the pitfalls of previous research and in the light of suggestions made by Good and Cooley, we felt that the first step in a process product study was to identify the processes occurring in a teaching situation typical of that being studied. That the identification of variables should be done across classrooms reflecting teaching styles typical of the methodological and psychological positions posited in science education, prompted the use of classroom settings representing the two psychological positions described by Schulman (1968). The student measures were selected to cover a range of outcomes in cognitive, affective and process areas.

Objectives of the Study

The overall purpose of the research was to study patterns of teacher behaviour and student outcomes in two settings using curriculum materials based on alternative psychological learning approaches. In addition to providing a comparison between these two treatments, both in terms of teacher behaviour and student outcomes, the study was intended to identify and analyze process dimensions and to relate them to student outcomes. The specific objectives of the study were the following:

a) To create and monitor two naturally emerging instructional settings based on alternative psychological approaches;

b) To identify process variables within the two settings based on specified criteria;

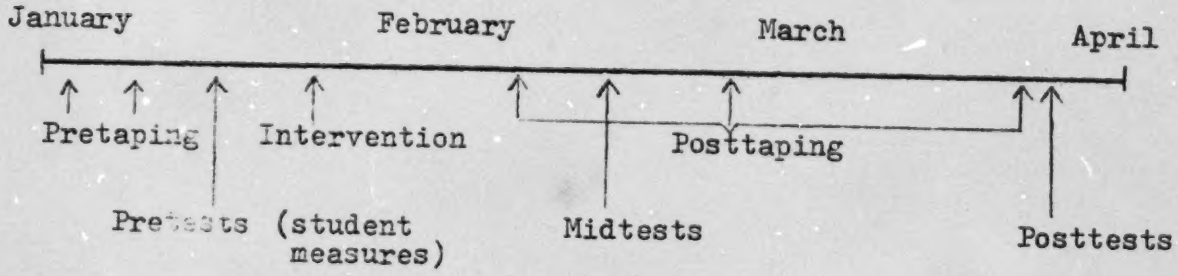
c) To analyze the intercorrelations and the stability of the process variables;

d) To compare student outcomes between the two instructional settings; and

e) To identify relationships that exist between teacher variables and student outcomes.

Procedures

The study, conducted over a four month period, involved pre- and post taping, the administration of student measures, and an intervention which was the introduction of the treatments. The two pretapings were intended to establish a baseline prior to the intervention and the post taping to observe the effects of the intervention. Student measures were given on three occasions during the three month period. These steps are shown below:



The procedures followed in conducting the study will be described in sections related to the objectives outlined above followed by a discussion of the sample used in the study.

The Creation and Monitoring of Settings

The two settings were based on the psychological positions described and analyzed by Schulman (1968). They included a cognitive

restructuring approach popularized by Bruner (1960, 1961, 1966) and a behavioural approach posited by Gagne (1963, 1965, 1966, 1974). The two positions are generic and represent foci at opposite ends of psychological and methodological continua; both have been influential in curriculum development and make different assumptions about teaching and learning. Those operating from the cognitive restructuring approach encourage children to make choices and to form images when presented with problems and or materials. These images are restructured in the basis of confrontation with additional data. The work of Hawkins (1965, 1969, 1974) and Samples (1969, 1970) offer methodological translations of this position which have been operationalized in curricula such as ESS, ES and MACOS*.

The behavioural approach described by Gagne is based on the identification of terminal behaviour and the setting up of conditions to achieve that behaviour. This becomes translated into curricula based on behavioural objectives and a hierarchy of learning outcomes structured in logical sequence. Programmes such as SAPA and ISCS* reflect the underpinnings of this approach.

The 12 teachers who participated in the study were divided into two groups each working in one of the two settings. Several steps were taken to insure that two distinct differences were created. First, the teachers participating in the study were interviewed prior to placing them in one or other of the two settings to assure some compatability between their teaching style and the setting.

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* ESS - Elementary Science Study; ES - Environmental Studies; MACOS - Man, A Course of Study; SAPA - Science A Process Approach and ISCS - Intermediate Science Curriculum Study.

Second, the teaching materials used differed for the two groups both in terms of approach and content. Third, separate training periods were used for the two groups in which teachers discussed readings and participated in workshop activities reflecting the two psychological positions.*

Teachers then taught a science programme based on the materials used in the workshops but were encouraged to adapt the materials to their own situation. An observer visited each classroom on several occasions during the experimental period collecting data on differences between the two settings and between teachers within the same setting. Also meetings were held separately with each group every third week to discuss problems, vet concerns, and review the application of the psychological positions involved.

The procedures, just described, to create different settings, were also a means of gathering data on the specific differences that existed and to determine if, indeed, such differences were sufficiently great to continue the study.

Identification and Analysis of Process Variables.

Because of the settings in which the study was conducted, the process variables would necessarily pertain to science teaching. In addition

* The description of the materials, the readings and the steps taken cannot be described in a paper of this length. A more complete description of the two psychological positions, a list of the teaching activities, and a summary of the observer's field notes can be had by writing to Marvin Wideen, Faculty of Education, Simon Fraser University, Burnaby 2, British Columbia, Canada.

three other criteria were used in their selection and analyses: (a) observability and quantifiability, (b) variance across settings, and (c) stability over time. These criteria not only provided benchmarks for identification but also directed the selection and use of instruments, procedures used in the study, and the methods of analyzing the process variables over time.

Observability and Quantifiability. It was recognized that variables that cannot be observed and quantified have little value for subsequent research. Thus, use was made of three observation schedules and one rating scale each of which provided numerical interpretations of teacher behaviour. The four, which are discussed below, were chosen to provide a fairly extensive range of instruments that would maximize the number or possible variables initially. The four instruments included: (a) The Greenway Oliver Rating Scale,* (b) Parson's Guided Self Analysis (GSA) (Parsons, 1968), (c) Flanders' Interaction Analysis System (FIAC) (Flanders, 1965) and (c) Gallagher's Classification System (GCS) (Gallagher, 1970).

The G-O* rating scale was devised to provide a general measure of openness as described by Joseph Schwab in his conditions for inquiry (1962). The scale is used to consider the topic of a lesson - the ways and means whereby a problem is solved or information is obtained by the pupil, and the solutions - to determine whether the

* A copy of this instrument along with information concerning its use is available by writing to the senior author, Faculty of Education, Simon Fraser University, Burnaby 2, British Columbia, Canada.

solution is a statement by the teacher or a discovery by the pupils and to provide a numerical rating for four levels of openness.

From the GSA observation schedule a number of process dimensions are obtainable such as pupil talk or information and leading questions. Seven such dimensions are provided in Table I. The FIAC was used to look at the "teacher response ratio", the "teacher question ratio" and the "pupil initiation ratio" which is also outlined in Table I. The GCS uses as its basis the "topic" or subject under discussion. Each is classified under instructional intent, level of conceptualization and style. This schedule was used to examine the teacher inquiry ratio and the student "introduction ratio".

The thirteen variables that were derived through the use of these four schedules and which are listed in Table I clearly represent only part of those that could have been reported. However, prior to analyzing the tapes the research team compared the four schedules and eliminated those which were redundant or those which could be described in only nominal terms. For example, teacher talk in GSA which was seen as the reciprocal of pupil talk and instructional intent and levels of conceptualization and style, which could only be described in nominal terms through the use of GCS were eliminated from the possible list.

Variance Across Settings. In order to determine the extent to which the process variables exhibited significant variation between

TABLE I

Process Dimensions Identified Through
The Use of Four Coding Schedules

Process Dimension		Acronym	Coding Schedule	Description
1.	Open/Closed Climate	OCC	G-O	The level of openness of a classroom as determined using the Greenway-Olliver system
2.	Pupil Talk	PT	GSA	The percentage of pupil talk reported in a classroom episode coded
3.	Question-Response	QR	GSA	The percentage of time spent by a teacher posing questions or responding to students
4.	Instruction	INS	GSA	All teacher talk intended to convey lesson related subject matter to the class
5.	Information and Leading Questions	IL	GSA	The sum of information and leading questions
6.	Leading and Probing Questions	LP	GSA	The sum of leading and probing questions
7.	Closure and Sustaining Responses	CS	GSA	The sum of closure and sustaining responses
8.	Sustaining and Extending Responses	SE	GSA	The sum of sustaining and extending responses

TABLE I (continued)

Process Dimension	Acronym	Coding Schedule	Description
9. Teacher Response Ratio	TRR	FIAC	An index which corresponds to the teacher's tendency to react to the feelings and ideas of the pupils
10. Teacher Question Ratio	TQR	FIAC	An index presenting the tendency of a teacher to use questions when guiding the content orientation of a class discussion
11. Pupil Initiation Ratio	PIR	FIAC	The proportion of pupil talk that is an act of initiation
12. Teacher Inquiry Ratio	TIR	TCS	The total number of question-oriented introductions divided by the total number of introductions
13. Student Introduction Ratio	SIR	TCS	The total number of student-introductions divided by the total number of introductions

the two settings, a repeated measures design was used in which settings and replicate were used as main effects. Since the difference due to setting involved the summation across pre and post intervention observations, it was not expected that differences would be evident due to this main effect. The main effect, replicate, reflected overall changes from one taping to the next for both groups combined and thus was of only passing interest. The interaction term which provided a measure of the differences from one observation to the next for the two treatments was of prime interest in this analysis. Differences at the 5% level of significance for process variables were accepted as showing significant variation across settings.

Stability Over Time. To analyze the variables over time, correlations were used to obtain an indication of the consistency from one observation to the next. It was expected that relatively higher stability coefficients would be evident between observations taken during the pre intervention period and those observations made during the post observation period, but that those which spanned the two would be considerably lower.*

Intercorrelations were also run between all the variables used in the study. These were viewed both in terms of their stability over

* The work of Shavelson and Dempsey (1976), however, suggests that processes measures such as those used in this study are not necessarily stable over time. They also indicate that global measures of teacher behaviour such as the 9-0 measure appear to be more stable than those involving frequency counts.

time and in terms of consistency from one observation to the next.

Student Outcomes in the Two Settings

To compare the student outcomes between the two settings an analysis of covariance was run using the pretest measures as covariates and the posttest scores as dependent variables. Treatment was used as a main effect. It was recognized that interpretations from this analysis had to be made with caution because of the differences among the individual classrooms. The intent had been to create two naturally emerging curriculum settings. As this was accomplished, it was obvious that while those working in the behavioural setting followed a very similar pattern of teaching, those using the cognitive restructuring approach differed considerably from each other in terms of the content and the approach. To aggregate the data without examining the differences among teachers within each group would have been to loose a rich source of variation. Thus, each teacher was also considered as an individual case study.

As a control, the measures were administered in two classrooms that were not involved in the study in any other way.

Student Measures. The student measures employed in the study are summarized in Table II. They included measures of self-concept, interest, cognitive preference, science content and science process. The subscales shown in Table II for student interest and self concept were derived through factor analysis.

The self concept measure used was the Sears Self Concept Inventory (Sears, 1966) which is intended to assess a child's expectation of

TABLE II

Student Measures Used in the Study

Measure and/or Subscale	Acronym	Description	Reliability
Self-Concept			
- convergent thinking	SCT	Items include those dealing with convergent thinking	.89
- sociability	SS	Items deal with social virtue, social relations and other aspects of sociability	.85
- divergent thinking	SdT	All items deal with divergent thinking	.85
- physical leadership	SpL	This included items from the original Sears Physical Ability subscale plus those associated with athletics	.83
- appearance	SA	Items are associated with the assessment of personal appearance	.73
Sequestial Test of Educational Progress	STEP	A measure of science content and process	.89
Observation	OBS	Score awarded on the basis of the number and quality of student observations	
Conflict Resolution	CR	Student response to a descrepant event were coded	
Figure Preference Test	FP	Students selected one of three figures graded in terms of their complexity	

TABLE II (continued)

Measure and/or Subscale	Acronym	Description	Reliability
Interest Inventory			
- analysis factor	IA	Items dealt with concrete aspects fitting things into a pattern	.90
- synthesis	IS	Items which look at the gestalt of a situation rather than the parts	.78
- artistry	ISR	Included non-science items of an artistic nature	.70
- social compliance	ISC	Included items having a production orientation and those that have a teacher compliance honor	.80
- passivity	IP	Items dealing with a more passive stance to doing science than others	.73

problem solving and completion tasks. Children were asked to answer the question : "Compared to other boys and girls my age, how do I rate now?" On a five-point likert-type scale anchored by "Not so good" and "Excellent". It was used in the study because of its extensive research and also because of a claim of a relationship to academic achievement. Five factor defined subscales were used which are listed in Table II.

The STEP test was used as a measure of science content and has been found to be a fairly good measure of academic achievement as well. As an indicator of process, students were provided with an object and asked to make observations. A score was awarded based on the number and quality of these observations. A second measure of student process was dropped from further analysis because of low reliability.

As a means of arriving at measures of the students' cognitive preference two measures were employed. The first involved the use of a discrepant event for which students were asked to provide an explanation. Their explanations were then coded using the categories description, mechanical, causal, magical and anthropomorphic. The second measure was a figure preference test in which students were given one of three pictures and asked to indicate their preference.

The interest inventory was made up of 52 items each describing an activity a student might be expected to do in school. A three-point response scale was used and ed by "Yes", "Don't know", and "No". Five factor scales are derived from the measure and shown in Table II.

Relationships Between Teacher Variables and Student Outcomes

Because of the relatively small number of teachers used in the study and the great amount of variation from teacher to teacher it was considered that the most appropriate procedure would be to treat each teacher as a separate case study in looking for relationships between certain process variables and changes in student outcomes. This was done by inspecting the class means for every measure to identify shifts that exceeded a half standard deviation. Where consistent shifts were in evidence, process variables were examined to identify relationships.

The Sample

The teacher who volunteered for the project taught in schools located in lower middle class areas in a metropolitan city area having 1½ million people. The placement of teachers in one or the other of the two treatment groups was done on the basis of rationalization rather than randomization. This procedure involved intervening teachers to determine which of the two settings they preferred following a meeting with the research team where the two approaches were described. Twelve teachers participated, five in the cognitive restructuring group and seven in the behavioural group. For some of the analyses two subjects from the latter group were dropped because of missing data.

The students group (N = 419) involved all that were in the 12 classrooms used in the study. Of these, 341 were in self contained

classrooms with an average enrollment of 26 students per class and the remaining 18 in an open area classroom. Table III shows the grade by sex break down for the student sample.

Table III

Grade by Sex Breakdown of the Student Group

Grade	Sex		Total
	Boys	Girls	
4	85	95	100
5	77	92	169
6	37	33	70
Total	199	220	419

Results

Monitoring of Settings

The purpose of monitoring the settings was to gain some indication at an early stage of the study that two different settings had been created. A minimal acceptance would have been that the two settings were, in fact, different. Further, it was hoped that differences would occur corresponding to the expectations generated from the work of the research team in operationalizing the psychological positions described by Schulman (1968). The observation made during the workshops, the after school meetings and in the classrooms clearly indicated that this objective of the study had been achieved.*

* Space does not permit a full discussion of these data. A copy of the summary of the field observer's notes is available on request by writing to Marvin Wideen, Faculty of Education, Simon Fraser University, Burnaby 2, British Columbia, Canada.

Identification and Examination of Variables

The data provided in Table IV includes F values from a repeated measures design. As indicated earlier, the interaction term, because it provides an indication of changes from one observation to the next, was of more interest in this analysis than the main effects. It can be seen from the table that for six of the variables significant F values were evident indicating that for these six significant shifts occurred after the intervention. The pattern of values for the different observations for these six variables are shown in Figures 1 through 6.

It can be seen that in general terms a somewhat similar pattern emerged. During the first two observations (replicates 1 and 2) the differences between the two treatments were minimal. This was particularly obvious in the case of OCC, PT, and SE; it was not as apparent for LP, TPR, and PIR. Following the intervetnion, which was first measured in replicate 3, a wide difference became evident and in the case of OCC, PT, SE and PIR the difference between the two groups was greater at this point than for subsequent observations. These differences persisted in observations 4 and 5 in most cases but generally to a lesser degree for each successive observation.

Two observations are clearly obvious from these results. First, the greatest difference between treatment groups tend to be evident immediately after the intervention. This occurred in five out of the six cases. Following this the differences between the treatments tend to become less over time. Secondly, in each case those in the second setting scored lower after the intervention.

TABLE IV

Summary of "F" Ratios for Analysis of Variance for the Thirteen Process Variables -- Treatment, Replicate, Treatment x Replicate

Variable	Treatment	Replicate	Treatment x Replicate
V. 1 OCC	3.28	0.84	*3.26
V. 2 PT	2.00	1.28	*3.90
V. 3 QR	0.95	2.02	1.72
V. 4 INS	0.06	1.99	1.17
V. 5 IL	0.26	0.46	1.50
V. 6 LP	1.00	2.56	**4.88
V. 7 CS	1.58	*2.76	0.14
V. 8 SE	3.21	**5.29	**4.04
V. 9 TRR	2.93	0.83	*2.70
V. 10 TQR	2.05	0.64	1.27
V. 11 PIR	0.00	1.00	*3.83
V. 12 TIR	0.65	0.62	0.98
V. 13 SIR	1.49	0.35	1.95

* Significant at .05 level of confidence
** Significant at .01 level of confidence

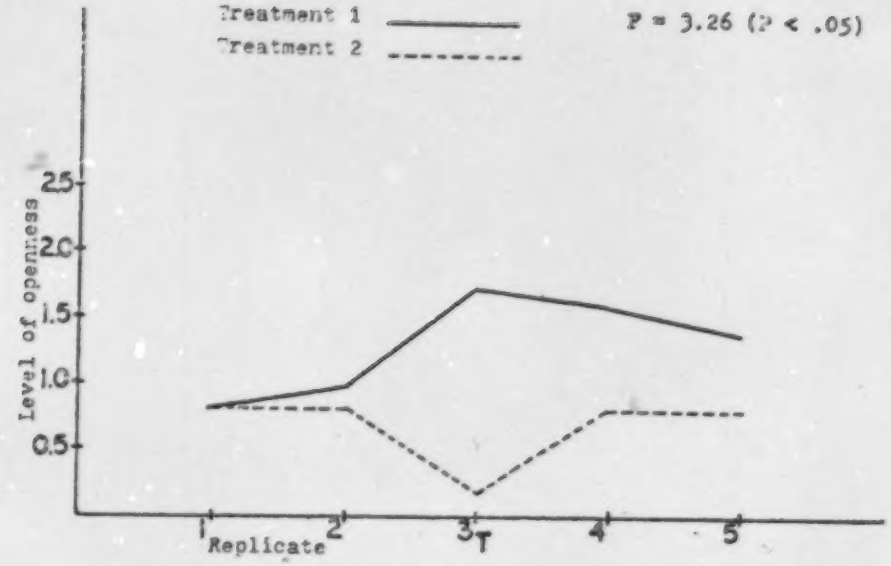

Figure 1. Interaction of treatment times replicate for level of openness

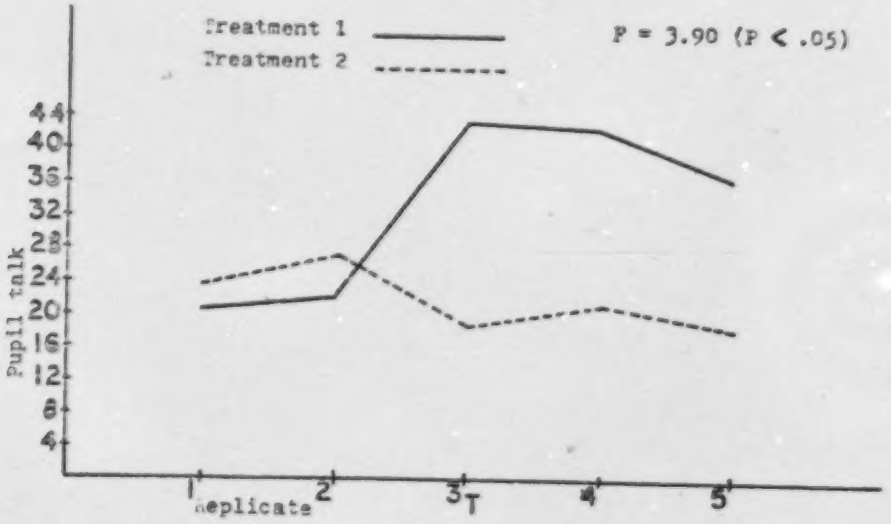

Figure 2. Interaction of treatment times replicate for pupil talk

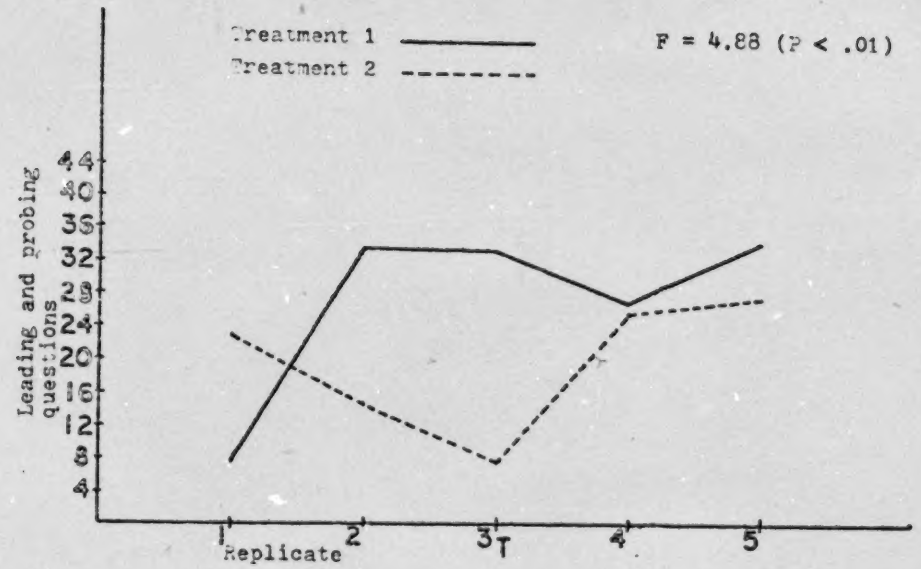

Figure 3. Interaction of treatment times replicate for leading and probing questions

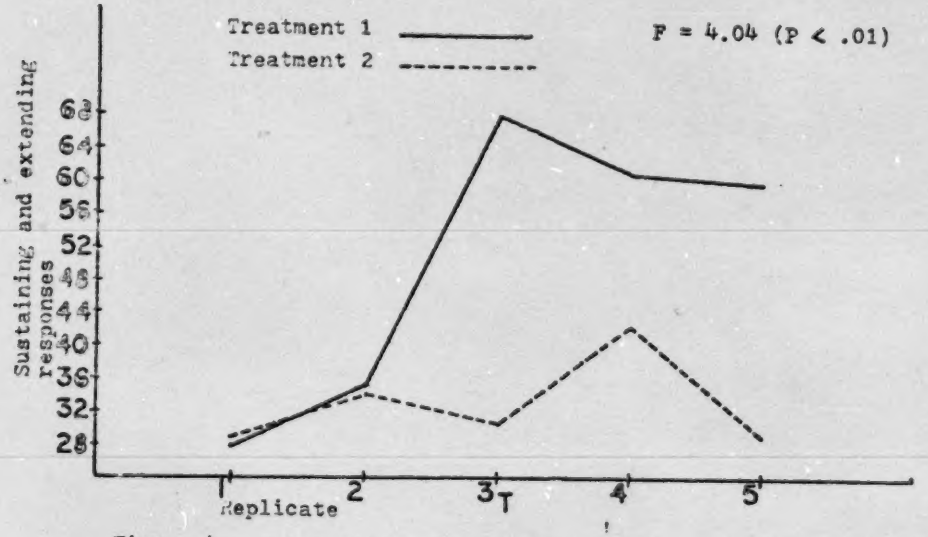

Figure 4. Interaction of treatment times replicate for sustaining and extending responses

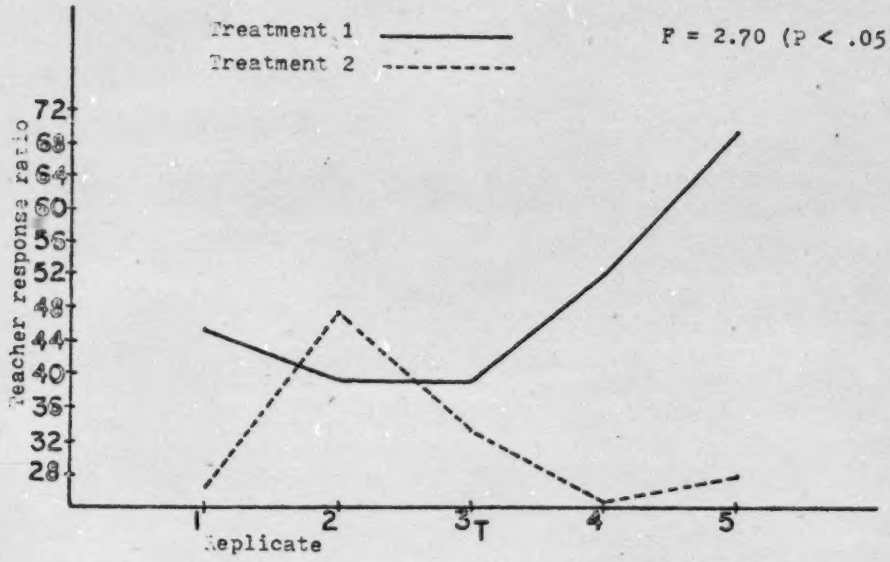

Figure 5. Interaction of treatment times replicate for teacher response ratio

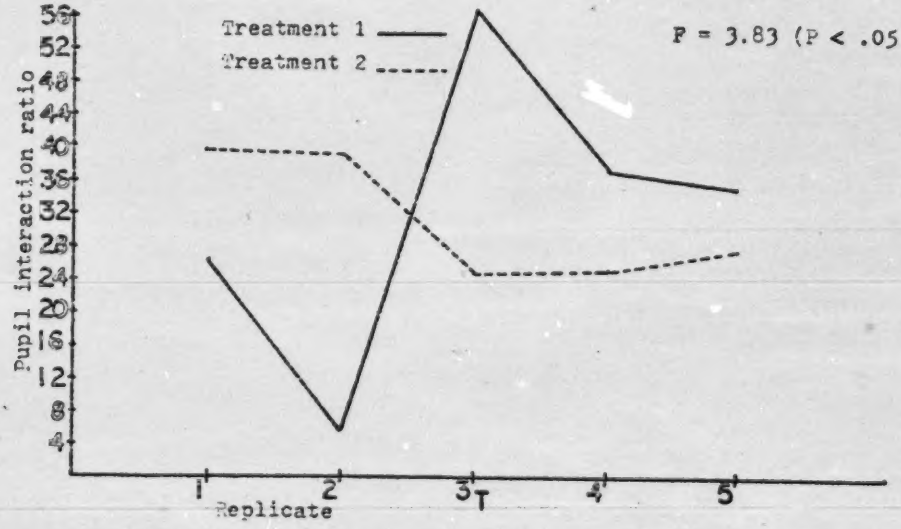

Figure 6. Interaction of treatment times replicate for pupil initiation ratio

The stability of the observations which are shown as coefficients in Table V reflect the tendency for those teachers who scored high on a variable at one observation to also score high on the next, and so on. When viewing the coefficients in the rows, it can be seen that for two of the variables OCC (levels of openness) and CS (closure and sustaining) the coefficients are consistently high ranging from .31 - .90 for the former and .54 - .94 for the latter. For some of the other variables, however, such as SIR (student introductory ratio) and PIR (pupil initiation ratio) negative correlations occur. For most of the variables consistently high correlations between successive observations were not in evidence.

When the coefficients are viewed column by column, it is evident that the most consistent pattern tend to emerge after the intervention between observations 3 x 4, 4 x 5 and 3 x 5. However, there are a number of exceptions to this particularly in the case of PT and INS. The coefficients were not as high and as consistent as expected between observations 1 and 2. Also it had been anticipated that a consistently lower pattern would emerge for observations between pre intervention and post intervention. However, a clear tendency in this regard was not in evidence.

TABLE V

Stability Coefficients - Process Variables

Variable	Number of Observations Spanned									
	I				II			III		IV
	1x2	2x3	3x4	4x5	1x3	2x4	3x5	1x4	2x5	1x5
1. OCC	41*	31	75	90	34	52	48	41	43	47
2. PT	40	47	-15	53	29	40	89	52	28	25
3. QR	32	31	27	48	58	24	05	53	50	60
4. INS	67	04	37	03	53	14	-30	27	48	39
5. IL	-37	22	65	26	19	10	44	53	-25	40
6. LP	14	54	22	80	-53	32	38	57	52	31
7. CS	59	71	89	93	94	54	90	95	65	94
8. SE	44	27	-39	62	40	11	82	64	40	64
9. TRR	55	24	45	56	31	36	01	80	10	47
10. TQR	49	26	73	42	82	14	67	40	40	49
11. PIR	41	-42	65	53	24	-22	17	55	18	51
12. TIR	34	16	75	66	22	43	44	-55	37	32
13. SIR	15	-29	69	74	-28	-02	89	-47	-37	-25

*Decimals have been omitted.

Student Outcomes

The results from ANCOVA using the two settings and the control group as three levels of the main effect are shown in Table VI. The mean values have been adjusted using pretest scores as covariates.

From an examination of the results, it can be seen that significant differences are in evidence in the case of the STEP test which was a measure of science content and for four subtests of the interest measure. No significant differences were in evidence for any of the other measures shown in the table.

In the case of the STEP scores students in both treatment groups improved by approximately one half a standard deviation with those in the cognitive restructuring group improving slightly more. The control group on the other hand dropped slightly. The differences shown by the adjusted means in Table VI reflect these changes.

The pattern of differences for student interest scores was consistent for each of the subscales with the adjusted mean values in Table VI reflecting the changes from pretest to posttest for the three groups. In every case where significant differences were in evidence the interest scores improved slightly or stayed the same in the two classes where no science was being taught (control group). In one case (ISC) the posttest scores for the control classes dropped slightly. For the two treatment groups, however, the posttest means were consistently lower than the pretest means with those students in the second treatment group tending to drop the

TABLE VI

Results from Analysis of Covariance for Student Measures

Measure	Treatment*	Adjusted Mean	S.D.	N	F	P
Self Concept						
SCT	1	50.82	11.71	157	2.61	.015
	2	53.13	13.02	159		
	3	53.01	10.84	41		
SS	1	47.89	9.68		1.80	.166
	2	48.64	10.67	-		
	3	50.52	9.36			
SdT	1	39.97	8.21		2.26	.106
	2	40.52	9.83	-		
	3	42.34	8.07			
SpL	1	23.86	6.98		2.83	.060
	2	24.44	6.06	-		
	3	25.74	5.22			
SA	1	13.26	3.88		1.41	.245
	2	13.53	3.53	-		
	3	13.61	3.01			
STEP	1	26.52	9.40		3.93	.021
	2	25.22	9.93	-		
	3	23.09	11.40			
OBS	1	2.91	1.69		.570	.566
	2	3.09	1.82	-		
	3	2.89	1.20			
CR	1	3.48	1.69		.756	.470
	2	3.73	1.50	-		
	3	3.81	1.03			
FP	1	55.11	8.40		1.518	.221
	2	54.78	8.60	-		
	3	56.82	6.76			

* 1= Cognitive restructuring
2= Behavioural
3= Control

TABLE VI (continued)

Measure	Treatment*	Adjusted Mean	S.D.	N	F	P
Interest						
	1	41.49	7.19		7.04	.001
ID	2	39.80	8.54	-		
	3	43.51	5.70			
	1	54.11	7.49		4.87	.008
IS	2	52.14	8.76	-		
	3	55.67	6.84			
	1	31.64	5.92		4.45	.012
ISR	2	30.61	6.10	-		
	3	33.04	5.79			
	1	30.01	5.35		4.40	.013
ISC	2	28.88	6.44	-		
	3	31.15	4.65			
	1	22.52	3.50		1.90	.152
IP	2	22.14	3.43	-		
	3	23.03	2.98			

* 1= Cognitive restructuring
  2= Behavioural
  3= Control

most. The one subscale on which the two treatment groups remained approximately the same was ISR which contained artistic items of a non-science nature. The differences in mean values in this case was caused by an upward shift in the scores of the control group.

Process Variables and Student Outcomes

The identifying of relationships between student outcomes and process variables was done by considering each teachwas an individual case. The first step was to calculate the gain or loss scores exceeding a half standard deviation for each classroom for the various measures. A corresponding "+" or "-" entry was made in a matrix shown in Table VII. The process variables for each teacher were then reexamined in light of these data to identify relationships that might have occurred. Since time and space does not permit a detailed discussion of each teacher, I will briefly discuss three teachers whose profiles of processes variables for the five observations illustrate the two relationships evident in this study.

In the case of teacher 4, who worked in the cognitive, restructuring setting a consistent pattern of gain scores were in evidence for the self concept scores. Although not shown in the table, it was also evident that the interest scores from the students in this teacher classroom dropped among the least of the teachers. On the process variables, this teacher scored consistently higher on those variables having to do with the use of questions and lower

Matrix Showing Changes of One Half SD Between Pre and for Twelve Teachers

Student Measure	Teacher 1	2	3	4	5	6	7	8	9	10	11	12
Self Content												
SCT				+					+			+
SS				+				-	+			
SdT				+				-				
Spb				+				-			-	
SA												
STEP	+					+		+	+	+		
OBS												
CR					+			+		+	+	-
Interest												
IA		-			-	-	-			-		
IS					-		-			-		
ISR										-		
ISC			-		-		-				-	
IP							-					-

on closing and sustaining responses. For example, teacher 4 scored high on the percentage of time spent posing questions and responding to students (QR), leading and probing questions (LP) and on the amount of pupil talk (PT) in her classroom; she scored low on closing and sustaining responses (CS). There was also a tendency for this teacher to retain the change that took place after the intervention measured at observations 4 and 5.

Teachers 5 and 7 were of interest because students in their classes dropped consistently on interest scores. The process scores for these two teachers who taught in the behavioural setting were virtually mirror images of those for teacher 4. Both scored low on PT, QR and LP. It was also evident in both cases that the two were less affected by the intervention and returned to their pre intervention pattern of teaching by observations 4 and 5.

Summary and Discussion

The small number of classrooms used in this study and the selection of those classrooms limit the extent to which one can generalize the findings from this study. The main findings can be summarized as follows:

a) Six process variables were identified that met the criteria used in the study. These were OCC (open and closed climate), PT (pupil talk), LP (leading and probing questions), SE (sustaining and extending responses) and PIR (pupil interaction ratio). In each case, these were higher for the teachers working in the cognitive restructuring group.

b) The largest differences between process variables occurred immediately after the intervention.

c) The process variables were not found to be stable over time.

d) Student interest scores dropped consistently in those classrooms where science was being taught with the largest discrepancies between pre and posttest scores occurring in the behavioural setting.

e) Science content scores were improved through instruction.

f) The use of a high level of questioning and a high percentage of student talk was positively related to student scores on self concept. Low scores on these variables were evident in classrooms where drops in entry were evident.

The six process variables identified as a result of this study were open/closed climate (OCC), pupil talk (P8), sustaining and extending responses (SE), leading and probing questions (LP), teacher response ratio (TRR) and pupil interaction ration (PIR). These six variables are useful for further research in that they reflect the type of teacher and pupil behaviour that one can expect to differ when settings or approaches are used that resemble those described in this study. In addition, they are observable and quantifiable using existing observation schedules and the results provided in the paper give a prospective user some indication of the stability of the variables over time.

The relatively low stability coefficients were due to some extent to the intervention. However, the lack of high stability coefficients between observations made prior to the intervention and after the use of the program had reached a plateau suggest that what teachers do from one lesson to the next varies considerably, at least, relative to other teachers. This result would support the use of time series analysis. When the variance across the two settings was compared for the three observations following the intervention, it was obvious that the largest difference occurred at the third observation and lessened successively thereafter. This points to the need for multiple observations of teacher behaviour in studies of this type. It is obvious from these results that the use of a single observation of teacher behaviour can be quite misleading. The lack of stability of the process variables would seem to support the work of Shavelson and Dempsey (1976) who found measures of teaching behaviour to have limited generalizability.

The drop in interest scores is consistent with earlier research I conducted using the program Science A Process Approach (Wideen, 1975). While a complete explanation awaits further examination of the data and perhaps further research, one explanation could be that exposure to an activity through teaching takes the "edge off it" as far as interest is concerned. Since the newness is gone the tendency to select that activity is less. It may also confirm the notion that the conduct of schooling is such that it effectively "turns students off".

It is evident that the amount and type of questioning is related in some way to both the self concept of children and the interests they

develop in school. However, like many others results from this study, this can only be considered tentative until supported by further work.

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